MONITORING OF DEPENDENCY OF HOP MATERIAL FALL THROUGH ON SIZE OF GAPS AT NEW DESIGN OF SEPARATION ROLLERS

Martin Krupicka, Adolf Rybka, Petr Hermanek, Ivo Honzik
Czech University of Life Sciences Prague
krupicka@tf.czu.cz

Abstract. This paper deals with a roller conveyor, which forms a part of the separating machine for hops harvested from low trellises. The parameters, which influence the correct operation of this conveyor, are tested. For purposes of testing a model of a roller conveyor had been designed and made in the previous season, which was subsequently tested in a series of experiments with the object to integrate it into a separating machine. There was tested the dependency of hop matter fall through on the size of the gap between the rollers. Measurements were made with standard rollers. New rollers were designed and made with different diameter and with less space between the sheet metal sleeves this year. The new design of the rollers allows for setting the smallest possible gap 24 mm. It is about 24 mm less than the original solution with diameter of the rollers 60 mm. Measurements were made with these new rollers and two parameters were tested this year. The first one was the size of the gap between the rollers and the second one was the rotation speed of the rollers. The measurements were carried out using a sample of hop matter harvested from low trellises. The dependency of fall through was determined for 2 gaps between the rollers and for three rotation speeds of the rollers. The measurements showed that when the gap between the rollers is as small (24 mm) as it can be, it is possible to separate 48 % more leaves than in the current solution. It was also found that changing the rotation speed of the rollers does not significantly affect the separation of leaves.

Key words: separation line, hop matter, roller conveyor, curve slump.

Introduction

Hops are nowadays used principally as one of the basic ingredients in hop brewing. Ninety-eight percent of the world hop production is grown for exactly this purpose [1]. Their use for other purposes is not mentioned in the world statistics. However, their importance in pharmaceutics is well-known, as besides the basic substances adding the basic sensory characteristics to produced beer (bitterness, aroma and full flavour), hops also contain a number of other substances of medical importance [2; 3]. For instance, flavonoids contained in hop cones appear promising as antioxidants and antivirals, particularly against the HIV virus [4].

This paper deals with separating the hop matter, which is harvested from low trellises. In this growing system, hop bines climb (twine) spontaneously up a special plastic network that is a substantial part of the low trellis system. This way eliminates a complicated hiring of labour for the most difficult operations, such as hanging and sticking of hop strings and hop-bine training [5; 6].

Majority of the traditional hop varieties cannot be grown on low trellises, for then they reach only 40 to 60 % of the yield they would reach on classic trellises [7]. The new “dwarf” varieties bred for low trellises should, according to the breeders and economists, reach at least 80 % of the yield reached by the varieties grown on the classic trellises [8].

In the Czech Republic, hop growing on low trellises is now in the experimental stage and the current acreage of low-trellis hop fields counts for only less than 50 ha [9].

For this growing technology different machinery is needed. The hops from low trellis are harvested by means of a mobile harvester, pulled by a tractor. The hop matter brought from the mobile harvester is then submitted to separation on a mechanical line, which is adjusted in a way compared to the classic mechanical picking line. The process of separation shall ensure that hop cones are separated from stems and leaves [10].

This paper is focused on the part of the separating machine, which is placed after the secondary picker, namely the roller conveyor with infinitely adjustable pitch of each roller. Its importance lies in separating hop cones from stems and leaves. The main function of the roller conveyor is to separate the hop matter into small-sized fraction formed by hop cones, leaves and fragments of the size smaller than the size of the gap between individual rollers, and into large-sized fraction such as stems, clumps, big leaves, which cannot fall through the rollers [11].

The right operation of the roller conveyor depends on several parameters. They are the rotation frequency of the rollers, roller profile, and the gap between individual rollers. To be able to determine the precise significance of these parameters, a model of such a roller conveyor was made in 2014, which is a scale copy of a real roller conveyor [12].

In the harvest season of 2014, a series of measurements were carried out in the laboratory of the Department of Agricultural Machines, FE, CULS Prague, focusing on the dependency of hop matter fall through on the gap size between the rollers. For these measurements we used the original rollers of 60 mm in diameter.

The object of this research was to design and implement a new structure of the rollers that would improve the separation of leaves and small impurities. Previous measurements from the harvest season of 2014 had found that the smaller is the gap between the rollers, the more leaves are separated [13].

The original structural design of the roller conveyor with rollers of 60 mm in diameter allowed for setting the smallest possible gap of 48 mm. When the roller diameter was enlarged by means of mirelon tubes, the gap reduced to 28 mm. Due to the newly designed rollers this gap got even smaller.

Material and methods

Model of roller conveyor

The model (Fig. 1) is a scale copy of the roller conveyor, which is used in the separating machine to separate hops grown on low trellis. The model has 9 rollers altogether, of 60 mm in diameter as a standard. The rollers are 600 mm long. The first roller is fixed to the frame, whereas it is possible to infinitely adjust the pitch of the remaining 8 rollers, thus changing the gap size between them. The space bellow the rollers was divided by means of KAPA boards to be able to determine the amount of the hop matter fallen through the rollers. The input of hops was provided by a belt conveyor, 600 mm wide and 1000 mm long.

Fig. 1. **Model of a roller conveyor**

The model throughput is 450 kg·h^{-1} of hop material and it is derived from the throughput of the real roller conveyor 2 m wide. This throughput corresponds to the peripheral speed of the conveyor belt 0.27 m·s^{-1} and rotation frequency of the conveyor rollers 0.67 s^{-1}. These values were set by means of frequency converters. Also the vertical distance of the belt conveyor from the roller conveyor corresponds to the real one.

For the purposes of the measurement the newly designed and made rollers were used, of 82.5 mm in diameter. Their metal welded collars have identical shape to those on the original rollers, i.e. 100 x 100 mm, with corners radiused by 20. On a tube there are 14 welded collars 39 mm apart. This way allowed for reaching a smaller gap between them (Fig. 2).

Fig. 2. **Laboratory roller conveyor with rollers fitted with welded collars**

Methodology of the measurement

The 2015 harvest season measurements used again the hop variety Sládek, harvested from low trellises. To prevent the hops from changing their characteristics during the separation, fresh hop matter was brought from the hop grower every single measurement day.

The hop matter sample was selected so that the percentage representation of individual components (hop cones, leaves) remained unchanged. A sample weighing 450 g (Fig. 3) corresponds to the throughput of the model roller conveyor, which is 450 $kg \cdot h^{-1}$. The sample contained 168 g of cones and 282 g of leaves. The average hop cone size was determined out of a sample comprising 100 pieces. The average value of the hop cone length was 28.3 mm and the average value of the cone diameter was 16.6 mm.

Fig. 3. **Hop matter sample evenly spread over the conveyor belt**

The measurement was conducted in such a way that the hop matter sample was mixed and evenly spread over the conveyor belt. The sample layer was approx. 40 mm high. Then the roller drive was switched on, followed by the belt conveyor drive. The hop matter was being continuously separated on the roller conveyor and thanks to KAPA boards, installed under each roller, was falling through into 7 containers. The individual components of the hop matter that fell in between the rollers were weighed accurate to 1 g.

For the season of 2015 several measurements were prepared. This paper deals with a measurement conducted with rollers of 82.5 mm in diameter. These rollers allowed for measuring two gaps. They were gaps of 28 and 24 mm. With both gap sizes between the rollers the dependency of hop matter fall through on the rotation frequency of the rollers was also examined. The basic rotation frequency of the rollers was 0.67 s^{-1}, then 0.8 s^{-1} and 0.94 s^{-1}.

Results and discussion

Comparison of two different gaps between rollers of identical diameter and basic rotation frequency

Based on the measured data, a curve of hop matter fall through was derived for two gap sizes between the rollers and is depicted in the graph of Fig. 4. With the rollers measurements were carried out for two gap sizes between the rollers, namely 24 and 28 mm. The graph clearly shows the dependency of the hop matter fall through for each gap (24 and 28 mm). When the gap is set to 24 mm, only 20% of all the matter falls through the first gap, which is by approx. 6% less compared to the gap of 28 mm.

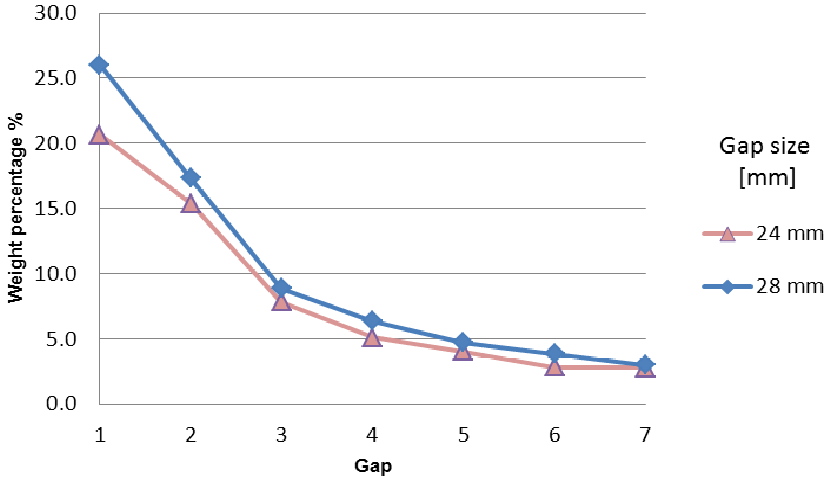

Fig. 4.**Weight percentage of the hop matter fallen through the separate gaps with rollers of 82.5 mm in diameter and rotation frequency of 0.67 s^{-1}**

As regards the leaves and cones in the waste, the best results in terms of leaf separation were measured with the gap of 24 mm (Fig. 5). 68.6 % of all leaves were carried into the waste. With the gap set to 24 mm, by 20.1 % more leaves were separated in comparison to the gap set to 28 mm. The following graph illustrates how many hop cones were carried into the waste. With the gap set to 24 mm the amount was 0.5 % of cones, whereas with the gap of 28 mm no cones ended up in the waste (Fig. 6).

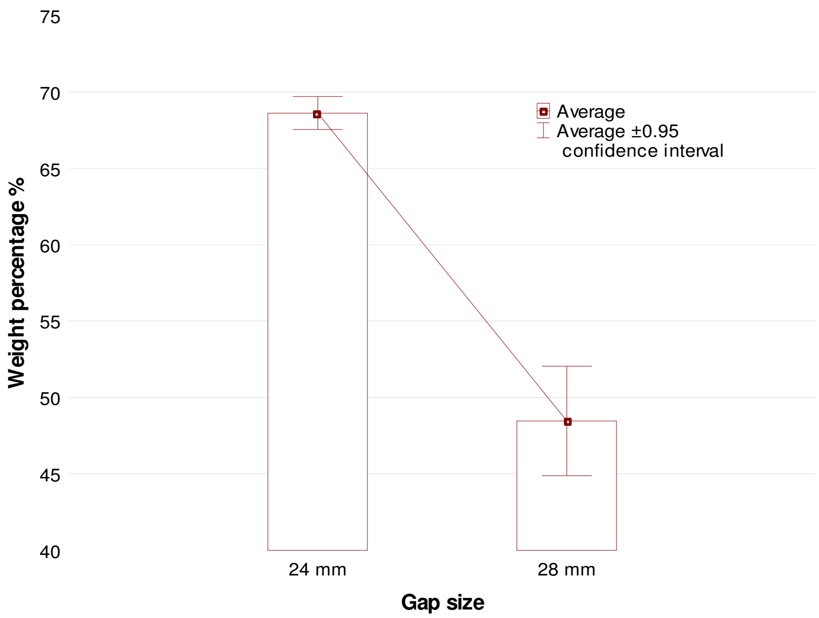

Fig. 5. **Weight percentage of the leaves and small-sized impurities in the waste with rollers of 82.5 mm in diameter and rotation frequency of 0.67 s^{-1}**

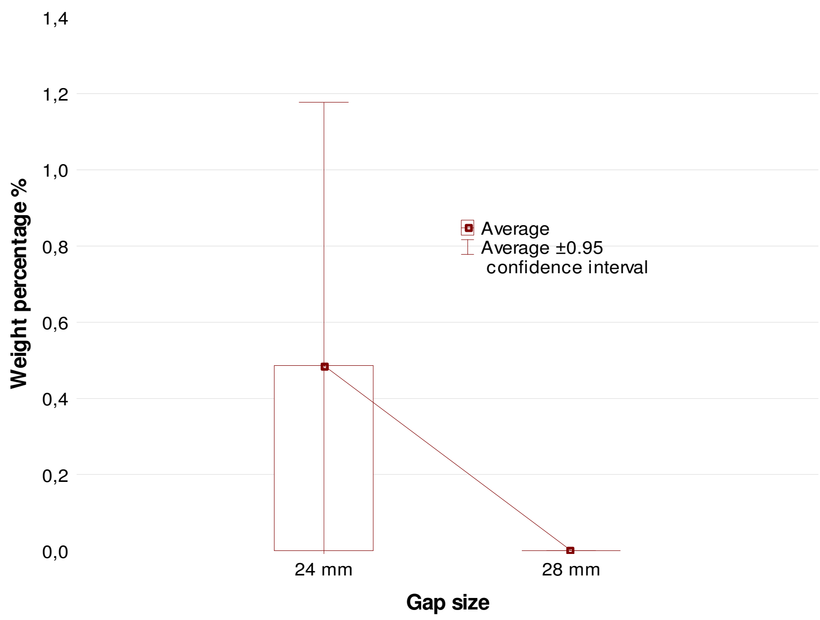

Fig. 6. **Weight percentage of hop cones in the waste with rollers of 82.5 mm in diameter and rotation frequency of 0.67 s^{-1}**

Dependency of hop matter fall through on the gap size and rotation frequency of the rollers

The processed measured data revealed that the rotation frequency of rollers has no significant effect on separation of leaves. Our assumption that increasing the rotation frequency of the rollers would cause a higher percentage of leaves and small-sized impurities to leave for the waste, was not confirmed. The following graphs in Fig. 7 and 8 illustrate the weight percentage of leaves and small-sized impurities in the waste for individual gaps and three rotation frequencies of the rollers. With the gap between the rollers set to 28 mm the best rotation frequency appears to be 0.94 s^{-1}. On the contrary, with the gap set to 24 mm, the best result was measured for the variant of 0.67 s^{-1}. Apparently, no dependency can be derived from the measured data.

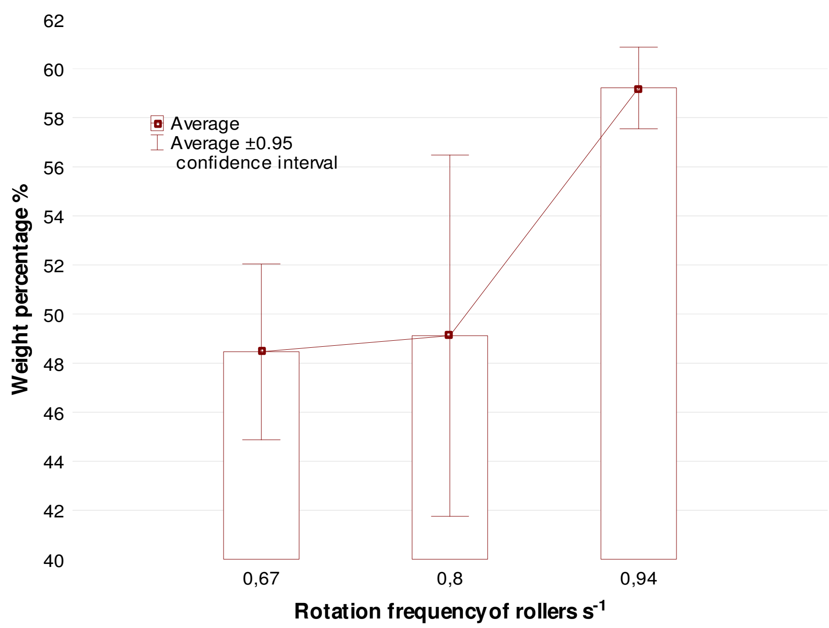

Fig. 7. **Weight percentage of leaves and small-sized impurities in the waste with rollers of 82.5 mm in diameter, gap of 28 mm and three rotation frequencies**

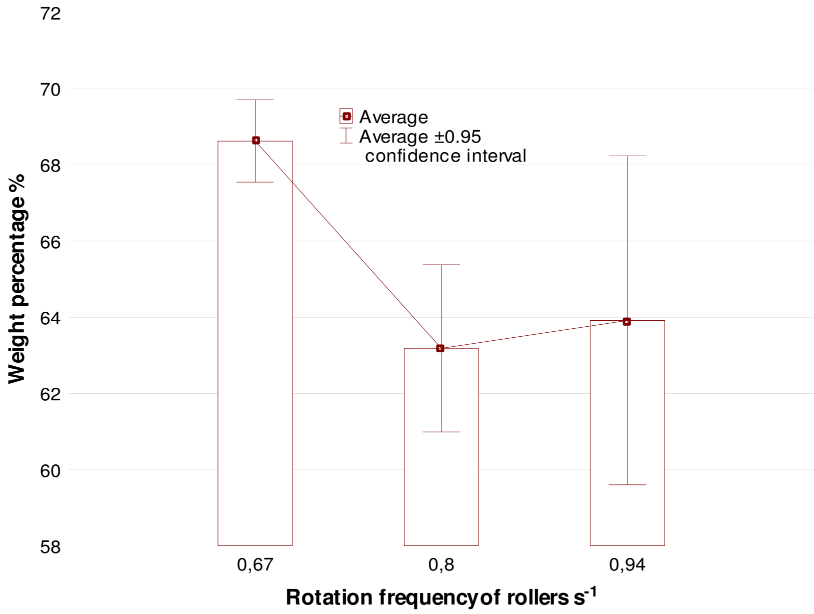

Fig. 8. **Weight percentage of leaves and small-sized impurities in the waste with rollers of 82.5 mm in diameter, gap of 24 mm and three rotation frequencies**

Conclusions

In the course of the 2014 harvest season measurements it was found that neither the roller diameter nor the gap size between them have any effect on separation of medium-length and long stems, which were separated perfectly in all cases. For this reason the measurements in 2015 were conducted using a hop matter sample, which comprised only hop cones and leaves. The amount of these components had been precisely defined.

The measurements confirmed that decreasing the gap between the rollers results in separation of more leaves and small-sized impurities. Leaves and small-sized impurities were better separated with the gap set to 24 mm. With this gap setting, less than 68.6 % of all leaves were carried into the waste. 0.5 % of hop cones fell into the waste.

No significant differences were found when comparing different rotation frequencies of the rollers. For this reason following measurements will be carried out with the basic rotation frequency of 0.67 s^{-1}.

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